

## **Status Report**

# **Development of a Concept for the ISOL Target Areas for RIA**

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The goal of this project is to develop and analyze design concepts for the ISOL target areas for RIA. Key criteria for this work are a maximum beam power capability of 400 kW, target changes with minimum downtime, good radiation protection, a high flexibility with respect to implementing new target concepts, as well as minimization of hazards and the classification of the facility. Such a study is necessary for a more realistic overall concept of the accelerator facility design where conventional facility, remote handling, radiation safety, and nuclear facility are integrated. The project is carried out in collaboration between MSU, ORNL, LLNL and LBNL and involves experts in rare isotope beam production and high power-targets, radiation characterization and protection, facility classification, remote handling, and material studies.

### **Organization of the collaborative effort and recruiting**

Efficient and frequent communication within the collaboration was regarded to be of particular importance for a project involving experts at different places and being so complex. For this purpose video and data conferences are being held on a biweekly basis for the presentation, discussion, and planning of the ongoing work. A server for document exchange and a webpage have been setup, where all presentations and the minutes of the meetings are posted. In addition to the biweekly videoconferences a 2-day working meeting was held at MSU on remote handling for both the ISOL and the fragmentation target areas and attended by ORNL and LLNL collaborators. A MSU collaborator participated in a simulation workshop organized by LLNL. A LLNL collaborator participated in a simulation workshop organized by MSU. Planning of the work started already prior to the receipt of funding via regular videoconferences and during a visit of a MSU delegation to ORNL/SNS to discuss remote handling issues.

A postdoctoral researcher (Valentin Blideanu) experienced in radiation transport calculations was hired at MSU. He started August 18 and works 50% on this proposal and 50% on the proposal on the "Development of a Concept for High Power Beam Dumps and Catchers, and the Pre-separator Area Layout for Fragment Separators for the Rare Isotope Accelerator Project". He will carry out radiation transport calculations for both areas.

### **Progress to date relative to the objectives outlined in the current R&D proposal**

The goals for Year 1 of this multi-year effort are to study the important aspects of the ISOL target area layout, to make pre-conceptual designs for the most critical items, to characterize the

radiation environment and its impact on the RIA facility, and to identify further R&D needs. Work has started on most of the topics outlined in the proposal and first results have already been achieved which are used as input in the iterative process required to develop a viable concept for the ISOL target area.

The *functional requirements for the ISOL stations* have been defined by MSU with input from ORNL and LLNL. Since RIA can be expected to run in campaigns with light ion beams for ISOL production alternating with heavy ion beams for in-flight fragmentation it is necessary to ensure a continuous operation of the ISOL system and if possible even a parallel operation of two stations. The latter scenario requires at least three target stations. If target R&D work is planned to take place in parallel to the isotope production a fourth station will be required. Desirable target lifetimes are 2 weeks minimum and preferable 1-2 month. In order to ensure continuous operation target change and commission times of less than 2 weeks are therefore required. This requirement will be used as a basis for developing the remote target change concept.

*First-order layouts for options for the ISOL stations* have been prepared by MSU for review and discussion by the collaboration. A first analysis of the advantages and disadvantages of the scenarios with either horizontal or vertical target systems was performed. It was concluded that the vertical concept offers substantial benefits in terms of a small footprint size and simpler remote handling; both are expected to reduce the facility costs. Furthermore, experience at ISAC can be used where a vertical concept is already employed for rare isotope production at 10% of the power level of RIA. The vertical concept was therefore adopted as the basis for the further study of the RIA ISOL scenario. A first layout for the ISOL stations and the required vertical modules was prepared taking *preliminary shielding calculations* into account as well as *first-order ion optical calculations* of the front-end optics and the pre-separator. Considering earlier radiation transport calculations, layouts for an *ISOL target area* with four target stations have been prepared by MSU. The 3D model of the latest version is now refined at ORNL for a more detailed analysis of the remote handling requirements. LLNL and MSU have started to analyze options for the implementation of *isotope harvesting* capabilities in the ISOL target area.

For the scope of this work a detailed design of *target/ion source systems* is not needed. Only feasibility studies are required to be able to analyze required services, remote handling, shielding requirements and nuclear inventory. Work on such generic target systems has started at MSU, ORNL and LLNL. Two different target types are considered. One is a ‘standard’ ISOL type target, in which the target material for the isotope production is bombarded directly with the primary beam. For this target type and a set of different ion sources the required services have been defined by MSU. The other target type is a two-step fission target where a primary target is used as a neutron converter surrounded by a secondary target with a fissionable material. In addition to the *liquid mercury target* as neutron converter as discussed in our proposal a *heavy water-cooled tungsten target* is studied as a possible alternative. ORNL has developed a conceptual layout for a compact mercury loop incorporated in the target/shielding plug assembly. MSU has prepared generic models for both target types for radiation transport calculations and thermal and decay heat analysis. Material damage calculations of a stainless steel container have been performed at LLNL using different versions of MCNPX and PHITS with excellent agreement of the results. First calculations for neutron production and beam heating in the primary target and fission heating in the secondary target have been performed at MSU and ORNL for both target types. These simulations are complemented by release time studies recently started at MSU. The first results indicate that in terms of isotope production via fission a very similar performance

can be expected for both targets. In order to study the feasibility of the heavy-water-cooled target further, a first thermal analysis of such a target has been performed and a concept for the primary target geometry and the cooling of the target is being developed at ORNL. Decay heat calculations have also started. Some work has also started on a *generic beam dump system for 400 kW p, d, or <sup>3</sup>He beams*. SRIM calculations and a thermal analysis for a water-cooled copper block have been performed at MSU as a first step towards a better understanding of the requirements of such a beam dump.

Based on earlier calculations performed at MSU *major shielding requirements* impacting civil construction and environmental protection have already been addressed in the first layout of the ISOL target stations and the target area and building. The simulation results obtained from the target studies will now be used for a more *detailed study of neutron transport and for radiation heating* close to the ISOL targets and beam dumps.

The *identification of maintenance intervals of components* in the ISOL area has started and will be completed as soon as results on material damage and activation analysis become available. This information will be a key component of a detailed analysis of the remote handling requirements.

No specific work has been carried out so far on facility classification and segmentation. This task will be taken up as soon as more realistic information on radiation levels and inventory is available.

### **Estimate of time needed to complete your R&D goals**

We are confident to be able to complete a first iteration on the development for a concept for the ISOL target area at a level that allows us to identify those areas where more detailed work is required. In the following year the work will concentrate on improved, more detailed concepts for the ISOL target area, components and remote handling at a level that can be used for engineering considerations. The most critical remote handling scenarios are planned to be tested with mock-ups and material studies will be carried out as far as required. Provided that similar funding is available, the effort for completing a realistic concept for the ISOL target area is not expected to be more than two additional years.

### **Summary of expenditures to date**

	Funds received	Personnel	Travel	Other
MSU	\$144 k (June 15, 2004)	14,661	428	0
LLNL	\$117k (June 2004)	23k	0	0
ORNL	\$184k (June 2004)	45,951	1,837	0